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The Economics of Solar Water Heaters

A GUIDE FOR EVALUATING THE COST-EFFECTIVENESS
OF ACTIVE SOLAR WATER HEATING SYSTEMS IN MASSACHUSETTS

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SECTION I INTRODUCTION

The time when solar water heating could be considered a novelty or a luxury has passed. The technology and economics of solar water heaters have made them practical for families in Massachusetts today. The reasons are several. One is the fact that it is possible to save much more money during the lifetime of the solar system than was spent on it originally. A second is that it works. A solar water heater system can provide 50% of your domestic hot water needs. And a third is that solar water heaters add to the resale value of the homes in which they are installed.

Other reasons for installing solar water heating NOW include the current economic climate, the tax incentives available at this time, and the HUD Grant Program. The cost of electricity and fossil fuels is soaring and thus placing a burden on family budgets already strained by inflation. At the same time, families seeking to meet these increased costs through increased incomes face higher tax obligations. Installing solar water heaters can be a way out of this economic trap, since it allows families to control at least a portion of their energy costs. A family can receive a grant for installing a solar water heater now and reduce their income tax burden at the same time, while continuing to benefit from the investment in the future.

However, while many families are convinced of the benefit of solar water heaters, they understandably want to know more about the economics of installing such a system in their home before making a commitment. It is for this reason that this guide was prepared. By using this guide, it is hoped that each family considering the installation of a solar water heater can determine its economic benefit and/or feasibility for themselves.

Section II of this guide explains how to perform a life-cycle cost analysis which balances the benefits against the initial cost of a solar system. Three methods of rating such a system are explained: the discounted payback period, the internal rate of return and a yearly cash flow method.

Price, quality, durability, utility rates, tax credits, grants, etc. are among the many factors one should consider in purchasing a solar system. A detailed explanation of these considerations is given in Section III.

Section IV introduces and explains the tables which have been developed and included at the end of this guide in order to help you determine the economic benefits of a solar water heating system for you and your family.

SECTION II ECONOMIC METHOD: THE LIFE-CYCLE COST ANAYLSIS

Most consumer goods, such as food, yield an immediate satisfaction or else enduring satisfaction which is impossible to measure, as in the case of a TV. It is usually fairly easy, when considering a purchase, to weigh the cost against the expected satisfaction.

A solar water heater, like an electric or gas water heater, delivers hot water. Yet, the solar water heater is far more expensive than the other two. How can an expensive solar water heater be a better deal than a cheap gas or electric model? The benefits you get from a solar water heater are measurable, yearly amounts of "free" energy from the sun for as long as the equipment lasts. This translates into yearly dollar savings. In order to measure the benefits, it is necessary to add up the expected solar energy contribution for the entire lifetime of the solar water heater and compare this to the initial cost. Economists call this type of analysis LIFE-CYCLE COST ANALYSIS (LCC). By considering what the equipment will produce over its life-cycle, one can discover if the overall benefits exceed the costs, and if so, by how much. By performing life-cycle cost analyses for various types of water heaters, it is possible to compare conventional and solar water heaters and also various solar water heaters among themselves. Though a conventional gas or electric water heater is cheaper to buy initially, it may prove very expensive to run over its lifetime due to rising fuel costs.

To make use of the life-cycle cost analysis, one should examine at least three methods of rating the value of an investment such as a solar water heater. No one method gives the complete picture, but two or three methods together can be used for comparison purposes. These rating methods are:

1. The discounted payback period
2. The internal rate of return
3. A yearly cash flow table

If you are intending to buy a solar energy system with cash, the first two methods--the discounted payback period and the rate of return-- give the most useful indication of its value. If your purchase is to be financed with a loan, a yearly cash flow analysis will be useful as well.

The DISCOUNTED PAYBACK PERIOD tells you how many years it will take for the accumulated savings from the solar water heater to equal its purchase price. (Because of inflation, your future savings will be worth less than an equivalent amount of savings today. Therefore, in this guide, we have discounted (reduced), by an appropriate amount ,the value of the future savings in order to give a fair evaluation of your solar investment.)

Unlike the discounted payback period, THE INTERNAL RATE OF RETURN takes into account the fuel savings expected over the system's entire lifetime and enables you to compare the savings from the solar investment with an alternative investment, such as putting the money in the bank or buying stocks or bonds. The internal rate of return is roughly comparable to yearly interest rates.

For equipment financed with a loan, a YEARLY CASH FLOW TABLE will show you how much your yearly loan payment will be offset by savings on your fuel bills. Since savings increase year by year due to rising fuel costs, each year a larger portion of the yearly loan payment is offset by the savings. For this reason, solar water heaters financed with a loan are about as cost-effective as those paid for in cash.

The cash flow changes according to the type of financing. A typical cash flow analysis is included as an illustration in Table III. However, a more detailed analysis is beyond the scope of this guide.

SECTION III FACTORS AFFECTING THE DECISION TO BUY

A. Price

This is one of the most important factors. Information from those who have purchased solar water heating systems shows that very similar systems may vary widely in price, yet the efficiency and durability of some of the higher priced systems may not yield sufficient fuel savings to justify their added cost. Purchase price is an item worth examining with care.

B. Quality and Durability

Generally, better quality equipment will last longer; and the longer a system lasts, the more money it will save, because yearly savings will increase at a greater rate as time goes on, due to fuel cost escalation. Examine the hardware, and, if possible, the installations previously done by your installer. If you have questions about what you should look for in purchasing a solar water heater, contact the Division of Conservation & Solar. We will provide you with a consumer pamphlet designed to help you avoid possible problems with purchasing solar energy equipment.

C. Utility Rates

Your own utility rates are another prime consideration. Needless to say, you will save more with a solar water heater if you are paying relatively high utility rates.

In order to make use of the charts in this guide, it is important that you determine, with accuracy, the rates you are paying for fuel. To do this, you will need to look carefully at your recent utility bills. Most utility companies still charge according to a "declining block" rate schedule.* Charges are for blocks of kilowatt-hours (or hundred cubic feet of gas) used--the first block costing more than the second, the second more than the third, etc. Look on your bill for the type of rate schedule applied to your bill and request a copy of the schedule from your utility company. To obtain the cost of the fuel a solar water heater will save you, consult the rate schedule and note the rate charged for the last block of energy you used, since it is this energy which the solar system will displace. (If you used very little in the last block, use the rate for the previous block instead.) The resulting cost will be in ¢/kWh (cents per kilowatt hour for electric) or ¢/CCF (cents per hundred cubic feet for gas). To the electric rate, add the "fuel adjustment per kWh" figure.

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* Some states are changing the rate structure of their utility companies in an attempt to reduce peak loads and encourage conservation. In Massachusetts, it is now possible to request experimental "time of use rates" which charge the highest prices during the periods of greatest demand.

Peak periods vary from utility to utility depending on their mix of customers. However, in the greater Boston area, peak periods are usually: during the day, when the sun will be shining; in the evening, when a solar water heater will have the most stored energy; and in the summer, when sunshine is at a maximum. Therefore, these rates should be favorable to solar energy users.

The sum will be the applicable electricity cost for you. For a gas bill, divide any extra charges by the amount of CCF used in the billing period and add this ¢/CCF figure to the above ¢/CCF cost. This will be the relevant overall cost of gas for you. Enclosed you will find a pamphlet entitled, "How to Understand Your Utility Bill," which should help you if you find your utility bills confusing.

Since separate oil-fired water heaters are rare, we have not included prices in the charts. For the sake of comparison, current oil prices of about 61¢ per gallon correspond to about 2¢ per kWh, taking oil burner inefficiencies into account. If you currently heat your water by a tankless system with a heating coil in the oil burner used for heating your home, savings through solar energy will still be possible, since the furnace will not need to operate at all during the summer months and will operate less during the winter--especially if you keep your thermostat low.

D. The Federal Tax Credit

Cost-effectiveness of solar energy systems has improved substantially with the passage of the National Energy Act which provides a tax credit of 30% for the first $2,000 and 20% on the next $8,000 invested in solar energy equipment. For most people, this is equal to a price reduction of $600 on a $2,000 solar energy system. Enclosed you will find a sample of the IRS energy tax credit form.

E. The HUD Grant

The Department of Housing and Urban Development is offering each homeowner a $400 grant toward the purchase and installation of a solar water heater. The Division of Conservation and Solar is administering this grant program for Massachusetts. Applications and details regarding the grant are obtainable from our office.

F. If You Plan To Sell Your House

Increasing fuel costs make solar equipment on a house a valuable feature if you want to sell the house in the future.

G. Fuel Price Increases

The economic performance of a solar water heater and any solar energy system is highly dependent on the price of fuel it saves. Since many economists are predicting an 8% per year cost escalation for fossil fuels and electricity, we chose this number in order to perform the economic analysis presented in this guide. In 1973 and 1974, prices for imported oil jumped about 400%. This was soon reflected in a near doubling of electric rates in New England which uses oil-fired plants to generate most of its electricity. The savings projected in this guide should thus be considered conservative. If fuel costs jump dramatically once again, so will the savings realized from solar systems.

SECTION IV EXPLANATION OF THE TABLES

A. Procedure Used to Produce the Tables

A mathematical computer program called FCHART has been in use for a number of years to predict the performance of various solar energy systems. The Division of Conservation & Solar used this computer program, a variety of utility rates, and solar equipment prices to arrive at the discounted payback period, internal rate of return, and other performance results for a solar water heater in the Boston area. Details on the type of solar water heater which was analyzed will be found in the Appendix.

B. Tables I and II

Tables I and II are central to this guide and can be used by homeowners to calculate whether a solar system would be financially practical under varying conditions. Certain assumptions form the foundation of the figures presented. They include: 1) that the solar water heater is expected to last 15 years; and 2) that all purchasers will take advantage of the federal tax credits. (See Appendix III, item D.) Further economic and system performance assumptions are discussed in the Appendix.

The only difference between Tables I and II is that Table II uses solar equipment prices for someone receiving the $400 HUD grant, while Table I is for the person not receiving the grant.

To use these Tables, first determine the price you are currently paying for gas or electricity. (See Section III, item C.) On the left side of the Tables, find the price nearest to what you are paying. Then look across to system cost and find the price closest to what you have been quoted and read off the four economic performance figures. An explanation of these figures appears under each Table.

C. Table III

This Table is an example of yearly cash flow for a solar water heater which is financed with a five-year loan. The amount of the tax credit is used as a down payment. Column 10 probably holds the most significance for the homeowner. As you can see, in the 6th year, when you have paid off the loan, the savings from your solar system will now be yours. The amount of savings will escalate each year due to the rise in fuel costs.

We hope that you have found this guide useful. Any comments or ideas on how to make it more helpful to the consumer will be welcomed by our office. Good luck with your decision!

TABLE I
Solar Water Heater Economics
For Non-HUD Grantees

UTILITY RATES		SYSTEM A INITIAL COST=2600 WITH CREDIT = 1880				SYSTEM B INITIAL COST=2300 WITH CREDIT=1640				SYSTEM C INITIAL COST= 2000 WITH CREDIT=1400				SYSTEM D INITIAL COST=1600 WITH CREDIT = 1120			
ELEC ¢/kWh	GAS $/CCF	FYNS	SVGS	PYBK	IRR	FYNS	SVGS	PYBK	IRR	FYNS	SVGS	PYBK	IRR	FYNS	SVGS	PYBK	IRR
7.5	1.49	$200	$1445	8½ YRS	14.0%	$210	$1720	7 YRS	17.0%	$206	$2000	6 YRS	19.5%	$208	$2325	5 YRS	24.0%
7.1	1.43	189	1280	9	13.0	199	1555	7½	16.0	196	1825	6½	18.5	198	2155	5	23.0
6.8	1.36	180	1115	9½	12.0	188	1390	8	15.0	186	1660	7	17.5	188	1980	5½	22.0
6.5	1.30	169	950	10	11.0	178	1225	8½	14.0	175	1500	7½	16.5	178	1820	6	21.0
6.2	1.23	159	785	10½	10.0	167	1060	9	13.0	165	1340	8	15.5	167	1655	6	19.5
5.8	1.17	149	620	11	9.5	157	895	9½	12.0	155	1170	8½	14.5	157	1480	6½	18.5
5.5	1.10	139	455	12½	9.0	146	730	11	11.0	144	1000	9½	13.5	147	1325	7½	17.5
5.2	1.04	129	290	13½	8.0	136	565	11½	10.0	134	840	10	12.5	137	1160	8	16.5
4.9	.98	119	125	14	7.0	125	400	12½	9.0	124	675	11	11.5	127	995	8½	15.0
4.5	.91	109	0	15	5.5	115	235	13½	7.5	114	510	11½	10.0	117	825	9	14.0
4.2	.85	99	–	–	4.5	104	70	14½	6.5	104	345	12½	9.0	106	660	10	12.5
3.9	.78	88	–	–	3.2	94	–	–	5.5	93	175	14	7.5	96	495	11	11.0
3.6	.72	78	–	–	2.0	84	–	–	4.0	83	10	15	6.0	86	330	12	9.5
3.2	.65	68	–	–	.5	73	–	–	2.5	72	–	–	4.5	76	165	13½	8.0
2.9	.59	58	–	–	–	63	–	–	1.0	62	–	–	3.0	66	0	15	6.0
2.6	.52	48	–	–	–	52	–	–	–	52	–	–	1.0	56	–	–	4.0

FYNS: First Year Net Savings. The savings possible in the first year of operation after maintenance and operating expenses. Since maintenance is calculated as a percentage of the system cost, FYNS figures are not identical for every system.

SVGS: Savings. The total savings possible, after payback, over the lifetime (15 yrs.) of the system (1978 dollars).

PYBK: Discounted Payback Period. The number of years it takes for the net system lifetime (15 year) savings to equal the purchase price.

IRR: Internal Rate of Return. This enables one to compare the returns on the purchase of the solar water heating equipment with other investments.

* The prices for Systems A & B are average; there are many higher priced systems on the market. The prices for Systems C & D are less than average and generally apply to the self-installer. With the costs of materials and labor constantly going up, all system prices can be expected to rise in the future.

TABLE II
Solar Water Heater Economics
For HUD Grantees

UTILITY RATES		SYSTEM A INITIAL COST=2600 WITH CREDIT & GRANT=1560				SYSTEM B INITIAL COST=2300 WITH CREDIT & GRANT=1330				SYSTEM C INITIAL COST=2000 WITH CREDIT & GRANT=1120				SYSTEM D INITIAL COST=1600 WITH CREDIT & GRANT=840			
ELEC ¢/kWh	GAS $/CCF	FYNS	SVGS	PYBK	IRR	FYNS	SVGS	PYBK	IRR	FYNS	SVGS	PYBK	IRR	FYNS	SVGS	PYBK	IRR
7.5	1.49	$204	$1800	7 YRS	17.5%	$206	$2075	6 YRS	20.5%	$209	$2320	5 YRS	24.5%	$211	$2635	4 YRS	32.0%
7.1	1.43	194	1560	7½	16.5	196	1910	6	19.5	199	2155	5	23.5	201	2470	4	30.5
6.8	1.36	184	1470	8	15.5	186	1745	6½	18.5	189	1990	5½	22.0	191	2305	4	29.0
6.5	1.30	174	1310	8	14.5	176	1580	7	17.5	179	1820	6	21.0	181	2140	4½	28.0
6.2	1.23	163	1145	8½	13.5	165	1415	7½	16.5	168	1655	6	20.0	171	1975	4½	26.5
5.8	1.17	153	980	9½	12.5	155	1250	8	15.0	158	1490	6½	18.5	160	1810	5	25.0
5.5	1.10	143	820	10½	12.0	145	1085	9	14.5	147	1325	7½	17.5	150	1645	5½	24.0
5.2	1.04	133	655	11	11.0	135	920	9½	13.5	137	1160	8	16.5	140	1480	6	22.5
4.9	.98	122	490	12	9.5	125	755	10	12.0	127	995	8½	15.0	130	1310	6½	21.0
4.5	.91	112	325	13	8.5	114	585	11	11.0	117	825	9	14.0	119	1145	7	19.0
4.2	.85	102	160	14	7.5	104	420	12	9.5	106	660	10	12.5	109	980	7½	17.5
3.9	.78	92	0	15	6.0	94	255	13	8.5	96	495	11	11.0	99	815	8	16.0
3.6	.72	82	–	–	4.5	84	90	14½	7.0	86	330	12	9.5	89	650	9	14.0
3.2	.65	72	–	–	3.0	74	–	–	5.5	76	165	13½	8.0	78	485	10	12.5
2.9	.59	62	–	–	1.5	64	–	–	3.5	66	0	15	6.0	68	320	11½	10.5
2.6	.52	51	–	–	–	54	–	–	1.5	56	–	–	4.0	58	153	13	8.0

FYNS: First Year Net Savings. The savings possible in the first year of operation after maintenance and operating expenses. Since maintenance is calculated as a percentage of the system cost, FYNS figures are not identical for every system.

SVGS: Savings. The total savings possible, after payback, over the lifetime (15 yrs.) of the system (1978 dollars).

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* The prices for Systems A & B are average; there are many higher priced systems on the market. The prices for Systems C & D are less than average and generally apply to the self-installer. With the costs of materials and labor constantly going up, all system prices can be expected to rise in the future.

TABLE III

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BLUE HILL        MA   42.22

****THERMAL ANALYSIS****
 TIME PERCENT INCIDENT HEATING WATER DEGREE
       SOLAR     SOLAR     LOAD    LOAD   DAYS
               (MMBTU) (MMBTU)(MMBTU) (F-DAY)
 YR    50.0     27.13     0.0    20.47  6334.

****ECONOMIC ANALYSIS****
SPECIFIED COLLECTOR AREA =              56. FT2
INITIAL COST OF SOLAR SYSTEM = $    1400.
THE ANNUAL MORTGAGE PAYMENT FOR   5 YEARS = $                216.
 1     2      3      4     5     6      7      8      9      10      11
             END             PROP   INC   BACKUP INSUR,  COST   SAVNGS   PW OF
     INTRST OF YR DEPRC    TAX   TAX    FUEL  MAINT  WITH   WITH    SOLAR
YR    PAID  PRINC DEDUCT  PAID SAVED    COST   COST  SOLAR  SOLAR   SAVNGS
 0       0    799      0     0     0       0      0    600   -600    -600
 1      87    671      0     0    17     143     28    371    -84     -79
 2      73    528      0     0    14     154     30    387    -77     -69
 3      58    370      0     0    11     167     32    404    -70     -58
 4      40    194      0     0     8     180     34    423    -62     -49
 5      21      0      0     0     4     194     36    443    -53     -40
 6       0      0      0     0     0     210     38    249    171     121
 7       0      0      0     0     0     227     41    268    186     123
 8       0      0      0     0     0     245     43    289    201     126
 9       0      0      0     0     0     265     46    311    218     129
10       0      0      0     0     0     286     48    335    237     132
11       0      0      0     0     0     309     51    361    257     135
12       0      0      0     0     0     334     55    389    279     138
13       0      0      0     0     0     360     58    419    302     141
14       0      0      0     0     0     389     61    451    327     144
15       0      0      0     0     0     420     65    486    355     148
THE RATE OF RETURN ON THE SOLAR INVESTMENT(%)=           10.5
YRS UNTIL UNDISC. FUEL SAVINGS = INVESTMENT                8.

UNDISCOUNTED CUMULATIVE SOLAR SAVINGS = $               1590.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH SOLAR = $      4191.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O SOLAR  = $      4637.
PRESENT WORTH OF CUMULATIVE SOLAR SAVINGS = $            446.
```

COMPUTER PRINTED PERFORMANCE DATA AND CASH FLOW

The system corresponds to "System C" in Table I. The 5-year mortgage rate is 11% with a $600 down payment (the amount of the tax credit). Fuel: 4.5¢ per kWh.

Column 6: Assuming a 20% income tax bracket, 20% of the interest paid on the mortgage is tax deductible.

Column 8: This represents 1% of the system's cost plus $15 for pump operation, maintenance, and insurance per year.

Column 11: The value in 1978 dollars of each year's savings.

APPENDIX

The solar water heater used in our analysis for the tables is designed to deliver 50% of a yearly water heating requirement of 6000 kWh. It is typical of many systems approved for the HUD Grant Program. It is an active system, and the solar collectors use water, anti-freeze, or air as the heat transfer fluid. Sunshine and ambient temperature data used in our calculations are from the National Weather Service for Blue Hill, Massachusetts. It is assumed that the collectors face due south and are tilted at 43 degrees, the approximate latitude of Boston and Blue Hill. The system has a 114 gallon tank and supplies 75 gallons of water per day at 140 degrees F.

The period of economic analysis (the life-cycle cost of the system) was chosen to be 15 years. Yearly maintenance, pump operation, insurance and anti-freeze replacement expenses are calculated at 1% of the system cost (after credit and/or grant) plus $15 (1978 dollars). Monetary values are discounted at the rate of 6% per year. The fuel escalation rate is 8% per year.

INFORMATION REQUEST SHEET

I'm interested in further information on solar. Please send me the following:

☐ HUD Grant Application

☐ Making A Good Solar Purchase
Focusing on solar domestic hot water systems, this leaflet includes such topics as, "The Deceptive Ad," "How to Differentiate Manufacturers' Claims," "Choosing the Right Contractor," "The Contract," and "Examining Warranties."

☐ Here Comes the Sun, August, 1978
A general handbook for Massachusetts residents providing information on various active and passive solar applications and economic feasibility, as well as addressing the problems most often encountered by consumers when purchasing solar equipment.

☐ A List of Massachusetts Solar Industries, February, 1979
A compilation of individuals and companies, located or operating in Massachusetts, which are involved in solar energy design, distribution, installation, research and manufacturing. Updates will be published periodically.

☐ Major Massachusetts Solar Installations, August, 1978
The first of a series of solar installation inventories, including commercial, industrial, institutional, agricultural, and large residential solar systems. Updates will be published periodically.

☐ Solar Grants Guide, September, 1978
A guide to solar grantsmanship to assist you in acquiring a better understanding of solar grant opportunities and to provide information on preparing a successful grant application form.

☐ Solar Water Heater Installation Guidelines, April, 1978
A manual for both homeowners and professionals, intended for anyone who wants to avoid common errors associated with the installation of solar domestic hot water heaters.

☐ A List of Solar Legislation in the State

☐ A Solar Energy Bibliography

☐ A List of Solar Water Heater Systems Approved for Use in the HUD Grant Program

☐ A List of Solar-Related Courses Offered in Massachusetts

☐ Other General Solar Information

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(Name)

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(Address)

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Mail this page to:
Massachusetts Office of Energy Resources
Division of Conservation & Solar
73 Tremont Street, Room 849
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For further information or questions on solar, call: (617) 727-7297.